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TITLE: PERMANENT MAGNET ROTATING ELECTRIC MACHINE

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ABSTRACT:

PURPOSE: To provide a permanent magnet rotating electric machine suitable for drum driving of LBP or the like in which magnetic flux distribution is a sinusoidal, the torque is high and cogging torque can be reduced.

CONSTITUTION: In a rotor R1 formed of a cylindrical magnetic body having a hole into which a rotating shaft is inserted in the center, a plurality of U-shaped slits 20 are provided in the periphery of this rotor at equal pitches with non-slit parts facing outward in a radial direction so that the widths (A part) of magnetic body parts between the adjacent U-shaped slits are equal to the widths (B part) of magnetic body parts which are the non-slit part in the U shape, and inside the U-shaped slits U-shaped permanent magnets or bond magnets 21 are provided, so as to magnetize the A parts and B parts of different polarity.

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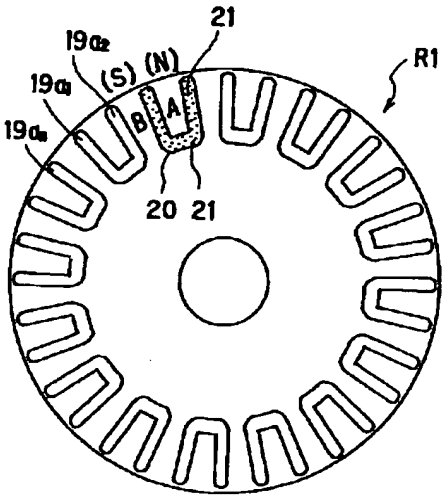
(54)【発明の名称】　永久磁石式回転電機

(57)【要約】

【目的】　ＬＢＰ等のドラム駆動に適し，磁束分布が正弦波で，かつ高トルク，コギングトルクが減少できるようにした永久磁石式回転電機を提供すること。

【構成】　中心に回転軸が貫通する穴を有した円筒形状の磁性体より成る回転子Ｒ１において，その外周に近接してＵ字形のスリット２０を複数個，等ピッチで非スリット部が半径方向で外向きで，隣接するＵ字形スリット間の磁性体部の幅（Ａ部）とＵ字内の非スリット部である磁性体部の幅（Ｂ部）を略等しく配置し，上記のＵ字形スリット内にはＵ字形永久磁石又はボンド磁石２１を充填して，Ａ部とＢ部を異極性となるように磁化するように構成した。



R1：回転子
20：Ｕ字状スリット
21：永久磁石又はボンド磁石

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【特許請求の範囲】

【請求項1】　中心に回転軸が貫通する穴を有する円筒形状の磁性体より成る回転子において，その外周に近接してU字形のスリットを複数個，等ピッチで非スリット部が半径方向に外向きで，隣接するU字形スリット間の磁性体部の幅（A部）とU字内の非スリット部である磁性体部の幅（B部）を略等しく配置し，上記のU字形スリット内にはU字形永久磁石又はボンド磁石を充填して，A部とB部を異極性となるように磁化した回転子を備えたことを特徴とする永久磁石式回転電機。

【請求項2】　請求項1で述べた複数個のU字形スリットに，永久磁石を内蔵した円筒形状磁性体2個を互いに180°／Zずらした位置で，その厚み方向に2極磁化したプレート状永久磁石を挟持して，上述のU字形スリット部の永久磁石によるA部とB部の極性と挟持された上記プレート状永久磁石によるA部，B部の各々の磁極性が一致するように，スリット部永久磁石を磁化してなる回転子を備えた永久磁石式回転電機。但し，Zは極歯の数である。

【請求項3】　請求項2記載の永久磁石式回転電機において，U字形スリット部に永久磁石を備えない構成とした永久磁石式回転電機。

【請求項4】　外周側又は内周側の少なくとも一方が細幅部で連結した2Z個のスリットを放射状に等ピッチで設けた外径2rの略円筒状の磁性体よりなり，2Z個のスリットのスリット部にはボンド磁石等の永久磁石を充填し，2Z個のスリットにより形成される2Z個の磁性体で成るポール部の半径方向長をaとし，nを1以上の正の整数，m＝1又は2又は3，k＝1又は2とし，a≧πr／2Zであり，Z＝m（3n±1）又はZ＝k（4n±1）又はZ＝k（5n±2）を満たし，かつ，2Z個の上記ポール部が交互にその外周で異極性に磁化されたことを特徴とする回転子を有する永久磁石式回転電機。

【請求項5】　請求項4記載の円筒形状磁性体において，その中心部の穴部にその回転軸方向長が円筒形状磁性体と略等しい永久磁石を装入し，2Z個のスリット部にも永久磁石が充填され，円筒形状磁性体の両端に中心穴部に装入した永久磁石と共に密着させるように，その半径方向に放射状で各々の形状が円筒形状磁性体の2Z個のポール形状に略同形状としたZ個のポールを等ピッチで設けた磁性体を2個互いにそのZ個のポールピッチの1／2ずらして配置し，それらの各々のZ個のポールが上記円筒形状磁性体の2Z個のポール部と1個おきに重なるようにし，回転軸方向に2極磁化したことを特徴とする回転子を有する永久磁石式回転電機。

【請求項6】　外周が細幅部で連結した2Z個のポールの円筒形状磁性体に永久磁石をその中空部に設け，請求項5に記載の半径方向にZ個のポールを持った磁性体を互いにZ個のポールの1／2ピッチ（180°／Z）ずらせて，そのポールが円筒形状磁性体の2Z個のポールと1個おきに重なるように密着させ，そのZ個のポールを持つ磁性体の各々に略円板状永久磁石を同心的に固着させ，更に該永久磁石の各々に円板状磁性体ヨークを固着させ，該ヨーク同士を磁性体より成る回転軸で連結し，少なくとも回転軸方向に磁化したことを特徴とする回転子を有する永久磁石式回転電機。

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【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は，レーザービームプリンター（以下LBPと略す）等に特に適した回転振動の少ない永久磁石型ステッピングモータ等の永久磁石式回転電機の改良に関する。

【0002】

【従来の技術】図12～図15により従来技術の内容・構成を説明する。

従来例1：図12は従来例1である2相式の永久磁石式ステッピングモータ又はシンクロナスモータの構成を示す斜視図である。同図において，固定子S′は2相を構成する第1の固定子部分1と第2の固定子部分2より成り，第1の固定子部分1はその内周側に相互に組み合わされる櫛歯状の極歯1a，1bとこれらの極歯1a，1b内に収納される環状コイル1cとより，また，第2の固定子部分2は同様に極歯2a，2bとこれらの極歯2a，2b内に収納される環状コイル2cとより構成される。ここで，極歯1aと2aは電気角で，例えば90°ずれて配置されている。R′は回転子で，この回転子R′は外周側に円周方向にN，S極が交互に配置されるように着磁された永久磁石3，中子4，回転子軸5より構成され，回転子軸5は軸受（図示せず）を介して固定子S′に支承される。この場合，固定子S′の各相のクローポールの分割角ピッチと回転子R′の着磁ピッチ角は相互に一致するように構成されている。このように，回転子が永久磁石よりなる多極のステッピングモータやシンクロナスモータは，界磁が永久磁石で与えられるため，回転界磁型電動機として効率がよく，多極のため，減速機を使用しないダイレクト負荷駆動等のため広く使用されている。特に，この構造のステッピングモータはオープンループ駆動ができ，速度発電機やエンコーダ等が不用で安価なシステムが可能となるため，多く使用されている。なお，このような永久磁石式の回転子磁極の磁束密度は図15のAに示すように正弦波状となる。この磁束密度の分布特性について，さらに詳述すると，次の通りである。図12の2相の永久磁石型（以下PM型という）の構造のものでは，ロータがリング状の永久磁石の外周にN，S交互に磁化されているため，エアギャップの磁束密度の最大値はハイブリッド型（以下HB型という）より小さいが，エアギャップ内の磁束分布は図15に示すようにHB型に比べ正弦波状に分布するため，鎖交磁束λは高調波成分をあまり含まず，このため

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回転トルクに振動成分をあまり含まず，振動の少ない回転となるもので，これをさらに，数式から解析すると次のようになる。計算の簡略化のため，2相機でトルクの式を誘導するが，次の（1）～（4）式より（5）式が，また（5）式で$\theta=\omega t$として，（6）式が求めら*

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*れる。なお，ここでλaはa相鎖交磁束，λbはb相鎖交磁束，ϕmは鎖交磁束の最大値，k_1，k_2は夫々定数である。また，iaはa相電流，ibはb相電流，imは電流の最大値である。

$$\lambda a=\phi m\{k_1\cos\theta+k_3\cos 3\theta\} \quad \cdots\cdots (1)$$

$$\lambda b=\phi m\{k_1\cos\theta+k_3\cos 3\theta\} \quad \cdots\cdots (2)$$

$$ia=Im\cos(\omega t+\alpha) \quad \cdots\cdots (3)$$

$$ib=Im\sin(\omega t+\alpha) \quad \cdots\cdots (4)$$

$$T=(d\lambda/d\theta)\,i$$
$$=\phi m\,Im\{k_1\sin(\omega t+\alpha-\theta)-3k_3\sin(\omega t+\alpha+3\theta)\} \quad \cdots\cdots (5)$$

$\theta=\omega t$として

$$T=\phi m\,Im\{k_1\sin\alpha-3k_3\sin(4\theta+\alpha)\} \quad \cdots\cdots (6)$$

（6）式の第2項が振動トルクを表わす。永久磁石型のものでは，$k_3=0$となることを考えれば，（6）式は振動成分が消えて，低振動回転モータとなるものである。

【0003】従来例2：図13及び図14は夫々従来例2に当たる3相3極のHB型のステッピングモータを示すもので，図13は横断側面図及び図14は図13のY－Y′線における断面図で，多種型の例を示すものである。各図において，6～8は固定子磁極，6a～8aは夫々内面側に設けられた極歯，6c～8cは夫々励磁コイルである。9は永久磁石10を挟着して成る回転子，11は回転子軸，12はケーシング，13及び14は軸受である。なお，このようなHB型の回転子磁極の磁束密度は図15のBに示すように略矩形波状となる。また，本構成のHB型の回転子では，N極とS極が軸方向に分離し，凸極の磁歯となっているため，ステータとのエアギャップの磁束分布も凸極磁歯の部分は磁束密度が均等に強く，凹部は零に近い分布となる。このためロータ磁束のステータコイルとの鎖交磁束λには空間高調波を多く含有することになり，回転トルクに振動成分を含有するものである。

【0004】

【発明が解決しようとする課題】ところで，上述の各従来例のものでは，次のような問題点があった。従来例1の場合：

①回転子がリング状の永久磁石の外周にN，S交互に磁化されているため，エアギャップの磁束密度の最大値は従来例2のHB型より小さいが，エアギャップ内の磁束分布は図15のようにHB型に比べ正弦波状に分布するため，鎖交磁束λは高調波成分及び回転トルクの振動成分を夫々少ししか含まず，比較的振動の少ない回転となる。しかし，本発明が適用用途としているLBP用としては，まだ振動特性の面で十分とはいえない。

②HB型のものに比べてトルクは小となる。

③2相式のため，ステップ角（分解能）が小さくできない。従来例2の場合：

※①従来例1の永久磁石式のものに比べ，図15に示すように磁束密度が大となり，トルクが大となる。

②しかし，HB型の回転子はN極とS極が軸方向に分離し，凸極の磁歯となっているため，ステータとのエアギャップの磁束分布も凸極磁歯の部分は磁束密度が均等に強く，凹部は零に近い分布となる。このため回転子磁束のステータコイルとの鎖交磁束λには空間高調波を多く含有することになる。したがって，回転トルクに振動成分を含有する。本発明は，従来のものの上記課題（問題点）を解決するようにした永久磁石式回転電機を提供することを目的とする。

【0005】

【課題を解決するための手段】本発明の永久磁石式回転電機は，上記課題を解決するために中心に回転軸が貫通する穴を有する円筒形状の磁性体より成る回転子において，その外周に近接してU字形のスリットを複数個，等ピッチで非スリット部が半径方向に外向きで，隣接するU字形スリット間の磁性体部の幅（A部）とU字内の非スリット部である磁性体部の幅（B部）を略等しく配置し，上記のU字形スリット内にはU字形永久磁石又はボンド磁石を充填して，A部とB部を異極性となるように磁化した回転子を備えた構成とした。この場合，複数個のU字形スリットに，永久磁石を内蔵した円筒形状磁性体2個を互いに180°／Zずらした位置で，その厚み方向に2極磁化したプレート状永久磁石を挟持して，上述のU字形スリット部の永久磁石によるA部とB部の極性と挟持された上記プレート状永久磁石によるA部，B部の各々の磁極性が一致するように，スリット部永久磁石を磁化してなる回転子を備えた構成とするのが望ましい。但し，Zは極歯の数である。また，U字形スリット部に永久磁石を備えない構成としても良い。また，外周側又は内周側の少なくとも一方が細幅部で連結した2Z個のスリットを放射状に等ピッチで設けた外径2rの略円筒状の磁性体より成り，2Z個のスリットのスリット部にはボンド磁石又は永久磁石を充填し，2Z個のスリットにより形成される2Z個の磁性体で成るボール部の

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半径方向長をａとし，ｎを１以上の正の整数，ｍ＝１又は２又は３，ｋ＝１又は２とし，ａ≧πｒ／２Ｚであり，Ｚ＝ｍ（３ｎ±１）又はＺ＝ｋ（４ｎ±１）又はＺ＝ｋ（５ｎ±２）を満たし，かつ，２Ｚ個の上記ポール部が交互にその外周で異極性に磁化されるように構成することもできる。この場合，上記円筒状磁性体において，その中心部の穴部にその回転軸方向長が円筒形状磁性体と略等しい永久磁石を装入し，２Ｚ個のスリット部にも永久磁石が充填され，円筒形状磁性体の両端に中心穴部に装入した永久磁石と共に密着させるように，その半径方向に放射状で各々の形状が円筒形状磁性体の２Ｚ個のポール形状に略同形状としたＺ個のポールを等ピッチで設けた磁性体を２個互いにそのＺ個のポールピッチの１／２ずらして配置し，それらの各々のＺ個のポールが上記円筒形状磁性体の２Ｚ個のポール部と１個おきに重なるようにし，回転軸方向に２極磁化した構成とすることが望ましい。また，図４に示すように，外周が細部で連結した２Ｚ個のポールの円筒状磁性体に永久磁石をその中空部に設け，前項で述べた半径方向にＺ個のポールを持った磁性体を互いにＺ個のポールの１／２ピッチ（１８０°／Ｚ）ずらして，そのポールが円筒状磁性体の２Ｚ個のポールと１個おきに重なるように密着させ，そのＺ個のポールを持つ磁性体の各々に略円板状永久磁石を同心的に固着させ，更に該永久磁石の各々に円板状磁性体ヨークを固着させ該ヨーク同士を磁性体より成る回転軸で連結し，少なくとも回転軸方向に磁化することが望ましい。

【０００６】

【作用】上述のような構成においては，外周上の磁極幅よりもＵ字状スリットの半径方向の２個のスリット部の長さの和を大きくとると，その半径方向のスリット部に充填された永久磁石（ボンド磁石）から発生する磁束が外周上の磁極に集まるため，そのスリットの半径方向の長さの和を十分大きくとれば，磁極の磁束密度を従来のＨＢ型のように大きくできる。しかも，Ｎ極とＳ極が交互に配置されるため，Ｎ極とＳ極の近接部では磁束密度が零となって反転していくため，ＨＢ型に比べて正弦波に近い形の分布となり，モータ回転時，低振動化に有利となる。又，ＨＢ型のものは，回転子軸方向に固定子鉄心内を磁束が通過するいわゆる３次元磁路となるから，磁気抵抗が大きくなるのに対し，本発明による永久磁石式回転電機は，回転子のＮ極から出た磁束は回転子軸に垂直な平面内で固定子コイルと鎖交した後，回転子のＳ極へ戻れる。従って，ＨＢ型のものに比べ，磁路長も短くなり，積層鉄板を回転軸方向に磁束が通らなくて良いため，磁気抵抗も小さくなる。又，回転子から見た固定子磁歯との対向面積もＮ極及びＳ極が固定子の全長に亙って対向できるため，トルクも増大する。なお，ＨＢ型のものでは約１／２の長さで回転子磁歯の半ピッチずれている。

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【０００７】

【実施例】以下図１～図１１に示す各実施例により本発明を具体的に説明する。

実施例１：図１乃至図２により本発明の実施例１の構成について説明する。図１は実施例１の回転子をとり出して示した横断面図で，同図に示すように，回転子Ｒ１は磁性体より成る薄い電磁鉄板をプレスで打ち抜き回転子とするか，鉄粉を焼結等で一体成形で作れるが，中心に回転軸が貫通できる穴を有した円筒形状の磁性体より成る回転子であって，その外周に近接して放射状に２Ｚ個，等ピッチでスリット１９ａ₁～１９ａｎを設け，１個おきに適当な長さ（深さ）でこれらのスリットを連結してＺ個のＵ字状のスリット２０を形成し，これらのＺ個のＵ字状スリット２０にボンド磁石２１を充填して，Ｕ字状の内側と外周で囲まれる磁性体部ＡとＵ字スリット２０が隣接する時のＵ字間同士の幅部の磁性体Ｂを各々その外周部において異極性になるように磁化することで，Ｎ極とＳ極がその外周で交互にＺ対数を有する永久磁石式回転電機とするものである。本発明の構造によれば，その外周長を２Ｚで割った長さ，すなわち磁極幅よりもＵ字スリットの半径方向の２個のスリット部長さの和を大きく取ることで磁極の磁束密度を永久磁石そのものの磁束密度以上にすることができる。なお，Ｕ字状スリット２０には，Ｕ字状のボンド磁石に代えて永久磁石を装着するようにしても良い。図２は固定子Ｓに対してエアギャップを隔てて，図１に示した回転子Ｒ１を組み込んで構成した実施例１の永久磁石型回転電機を示すもので，固定子Ｓは従来のＨＢ型ステッピングモータで回転子の歯数がＺ個と組み合わされるものなら同じものが使用できる。したがって，ケーシング１２，軸受１３，１４は図１４のものと同一の符号を付して示した。

【０００８】実施例２：本実施例のものは，図３に示すように構成される。即ち，図１に示した回転子Ｒ１と同一構造の２個の回転子素子１５ａ，１５ｂを，互いに１８０°／Ｚ度ずらして配置し，その中間に２極磁化した円板状永久磁石１６をサンドイッチ状に挟んで，回転軸で連結した回転子Ｒ２を図２と同じ固定子Ｓと組み合わせて構成したものである。本実施例のものは，実施例１の構成による効果と従来のＨＢ型のものによる更なる磁力の補強とが期待できる。即ち，本実施例のものでは，２極磁化した円板状永久磁石１６の外周にその内容が嵌合し，その外径は回転子外径以下で，その厚みは上述の２極磁石の厚みと同じ磁性体で，ラジアル方向に等ピッチの２Ｚ個のスリットを持ち，その外径又は内径で細部で連結している磁性体にてスリット位置を合わせて図３に示す２つの回転子素子１５ａ，１５ｂを磁気的に連結すると，ＨＢ型のものの２極磁化の永久磁石１６の磁束が回転子Ｒ２の全体にとどくことになり，しかもＵ字型に永久磁石が入っているので，Ｎ極とＳ極間の漏洩磁束も少ない強力なＮ，Ｓ交互磁化回転子となるものであ

る。

【0009】実施例3：本実施例のものは図4に示すように，回転子を磁性鉄板に菊花状に2Z個（この場合，Z＝4）のスリット17a1～17a8が設けられ，その外周が細部で連結したもので，スリットにはプラスチックマグネット等の永久磁石18a1～18a8が充填されて回転子R3が構成される。この時，外径を2r，回転子軸方向の長さをLとし，2Z個のスリットでできる2Z個（この場合，n＝4で8個）の半径方向の長さをaとすると，a≧πr／2Zの関係を満たし，上記の2Z個のボールの外周部をN極，S極交互に磁化する。回転子外周のボールである磁極幅は2πrL／2Zであり，スリット部磁石の法線と直角方向の面積はaLであり，＊両サイドの磁石から磁束が発生して2πrL／2Zに磁束を充分集中させるためには2aL≧2πrL／2Zであれば良く，a≧πr／2Zとなる。図5に示す回転子R3′は，図4に示す回転子R3においてボールは略同形状であるが，その内周が細幅部19で連結するように変形したもので，このように構成しても，N，S交互磁石となり得る。実施例の回転子はクローポール型固定子のいわゆる永久磁石型ステッピングモータ（図8）には有効な回転子であるが，従来のHB型ステッピングモータの固定子と組み合せて使用することもできる。この場合，2相ステッピングモータの場合には，次の（数1）で示される（7）式の関係が成立する。

【数1】

$$\frac{90^\circ}{Z} = \pm\left\{\frac{360^\circ}{4m} - \frac{360^\circ}{Z}n\right\} \quad \cdots\cdots(7)$$

また，3相ステッピングモータの場合には，次の（数2）で示される（8）式の関係が成立する。※【数2】※

$$\frac{60^\circ}{Z} = \pm\left\{\frac{360^\circ}{3m} - \frac{360^\circ}{Z}\left(n \mp \frac{1}{2}\right)\right\} \quad \cdots\cdots(8)$$

さらに，5相ステッピングモータの場合には，次の（数3）で示される（9）式の関係が成立する。★【数3】★

$$\frac{36^\circ}{Z} = \pm\left\{\frac{360^\circ}{5m} - \frac{360^\circ}{Z}\left(m \mp \frac{1}{2}\right)\right\} \quad \cdots\cdots(9)$$

上記（7）～（9）式にはその2Zとの関係式を示したが，いずれも左辺がステップ角を右辺の第1項は固定子の主極の成す角，第2項はその主極に最も近い回転子磁歯の位置であり，右辺もステップ角を表わす。この（7）～（9）式を整理すると，Z＝m（3n±1）又はZ＝k（4n±1）又はZ＝k（5n±2）となり，このZの関係式を満たすことが必要となる。4相ステッピングモータは2相機でのZの式に一部含まれる。ここで，nは1以上の正の整数，mは1又は2又は3，kは1又は2とする。

【0010】次に，図1又は図4なる回転子を固定子と組み合わせた時の磁路について説明する。本発明による図1又は図4に示す回転子は，図12に示す従来技術であるPM型ステッピングモータの回転子の代わりにPM型の固定子と組み合わせることで従来のPM型ステッピングモータより大きなトルクが期待できる構成としたものである。それは前述したように，磁極に永久磁石の磁束を集中させることで磁束密度を永久磁石そのものの磁束密度より高くできるためである。PM型の固定子はクローポール型であるため，例えば図4に示す回転子と組み合わせてもそのN極から出た磁束はクローポールの固定子磁路を通ってすぐ隣接のS極にもどれるので極めて有効である。しかし，従来のHB型ステッピングモータの固定子と組み合わせる場合は，N極から出た磁束は，☆例えば図7に示すように固定子磁路を通った後，必ずしも隣接のS極へもどれるとは限らないため，図4の構造の場合は磁路が開く場合があり，その場合効率は低下する。図1の構造のものではPM型は当然有効であるが，HB型固定子でも図6に示すように磁路は必ず一点鎖線で示したように閉磁路となるため，極めて利用範囲の広い発明といえる。なお，図1，図6，図7に示す各回転子はZ＝16とした場合の例である。

【0011】実施例4：図8は本発明の実施例4の構成を示す縦断正面図，図9は図8の各構成要素の分解斜視図である。本実施例のものは図1に示す実施例1のロータ21の両サイドに，外周方向にZ個のボールを持った磁束分配板22又は23を，そのボール形状が図4の2Z個のボール形状にほぼ同寸としたものを設け，図9に示すように2個の磁束分配板22又は23をそのZ個のボールピッチの1／2ずらして，図1のロータの2Z個のボールに密着させ，非磁性体より成るロータ軸24等で固定し，軸方向に2極磁化してロータとするものである。なお，磁束分配板23は1枚の鉄板を部分的に半抜して形成したものである。図9ではロータ21を構造の相違する磁束分配板22と磁束分配板23で挟むように構成した場合を図示したが，ロータ21を同一の2個の磁束分配板22又は磁束分配板23で挟むように構成しても良い。その働きは，永久磁石が回転軸方向に2極磁

化され，上記の磁束分配板２２又は２３で永久磁石の磁束を受けたものを，Ｚ個のポールで２Ｚ個のポールの１個おきに，Ｎ極とＳ極となるように磁束を２Ｚ個の磁性体ロータヨークの両側より分配供給するものである。この時，２Ｚ個のスロット間の永久磁石は回転軸方向に磁化されているため，２Ｚ個のポール間での漏洩はある程度防ぐことができる。図８の本発明品ロータを軸方向に磁化した後，２Ｚ個間のスロット部の永久磁石（マグネット）のみラジアル磁化される程度の着磁電流にてラジアル磁化を追加すると，２Ｚ個のスロット間磁石はラジアル方向に，又ロータ中心部の磁石はアキシャル方向に磁化されたままなので，２Ｚ個の磁性体の漏洩も防ぐことができ，強力なロータの磁極が形成される。なお，実開平３－１２４７７２号公報に示す先行技術では，２枚の櫛歯ロータヨークを組み合わせプラスチックマグネットを充填する案が示されているが，櫛歯ヨークはその構造よりその軸方向に曲げられてロータ外周で磁歯となる部分の厚みは板厚で決まり，その櫛歯幅は極数が増えた場合細くなり，全体にポールは針金状となり，先端まで永久磁石の磁束を送るには磁気抵抗が高くなり，高トルクは期待できない。本発明のものでは，図４で示したａを適切に選べばこの問題は解決できる。又櫛歯では多極となった時，ポールが針金状のためその位置精度が曲がりのため良く出ないという問題もある。本発明は鉄板をプレスで抜くので精度は良い。

【００１２】実施例５：図１０，図１１は夫々本発明の実施例５の構成を示す縦断正面図及び分解斜視図である。図１の２Ｚ個の磁性体で挟持されたスロット部は，プラスチックマグネット等の永久磁石を充填してなる回転体２５の両サイドに図１０及び図１１に示すように，磁束分配板２６ａ，２６ｂを図９と同じ位置関係で１／２ピッチずらして密着させ，その外側両サイドに薄厚のネオジウム等の永久磁石２７ａ，２７ｂを配置し，更にその外側両サイドに磁性体２８ａ，２８ｂを密着させ，この磁性体を磁性体回転軸２９で上記の２Ｚ個のポールの内径空洞部で連結してから，２極に磁化することにより２枚の永久磁石の磁束が各々Ｎ極，Ｓ極となるように２ｎ個のポールを１個おきに磁化して，図８と同じ効果が得られる。２個の永久磁石２７ａ，２７ｂは磁性体回転軸２９によって固定子を含む磁路を形成し，強力な磁界が作れる。図１０，図１１の構成において，磁束分配板２６ａ（２６ｂ）と永久磁石２７ａ（２７ｂ）の間に磁性体２８ａ（２８ｂ）のような磁性板を入れると，更に強力な磁界が作れる。

【００１３】本発明の上述した各実施例を示した図１～図１１のロータは，従来のＰＭ型２相機であるクローポールステータをボビン巻きし，フェライト等の円筒リングコイルの外周をＮ，Ｓ極交互にＺ対数に着磁したロータの代わりとして使用すれば，従来のＰＭ型モータより高トルクとなり得るが，上述したこのＰＭ型２相機のクローポールは櫛歯状ポールを曲げてステータ内径とするため，曲げたポールのスプリングバックの影響でエアギャップの均一性は良くなく，そのため振動等で不利である。これに対し，ステータを図６に示すように従来のＨＢ型ステータとし，本発明ロータと組み合わせるとエアギャップも均一になり本発明の真価が更に発揮される。

【００１４】図１５は従来のＨＢ型と本発明の例えば図１の１磁極の永久磁石からの磁束密度を比較した概略図であり，ＨＢ型のものは磁束密度が図１５のＢに示すように矩形波となるのに対し，本発明のＮ極，Ｓ極交互型のものでは，同図Ａに示すように正弦波状となることが示されている。

【００１５】

【発明の効果】本発明の永久磁石式回転電機は上記のように構成されるから，次のような優れた効果を有する。

❶ＨＢ型ステッピングモータと同等の高トルクと従来のＰＭ型以上の低振動，低騒音特性が安価な方法で実現でき，又多極化も可能である。

❷固定子と回転子の対向面積が従来のＨＢ型の２倍となるため，その分，鎖交磁束を増加できる。

❸ＨＢ型回転子のように凸極の磁歯でなくＮ極，Ｓ極が隣接するため，磁束密度が正弦波状に分布され，固定子無励磁のコギングトルクが減少でき，マイクロステップ駆動時のステップ角精度も向上する。

【図面の簡単な説明】

【図１】本発明の実施例１である回転電機の回転子の横断面図である。

【図２】図１の回転子軸を含む縦断正面図である。

【図３】本発明の実施例２の構成を示す縦断正面図である。

【図４】本発明の実施例３である回転電機の回転子の横断面図である。

【図５】本発明の実施例３の図４のものを変形して構成した回転子の横断面図である。

【図６】実施例１の回転子と固定子の磁束の状況を示す説明図である。

【図７】実施例１の回転子と固定子の磁束の状況を示す説明図である。

【図８】本発明の実施例４である回転電機の回転子の横断面図である。

【図９】図８の分解斜視図である。

【図１０】本発明の実施例５である回転電機の回転子の横断面図である。

【図１１】図１０の分解斜視図である。

【図１２】従来技術のＰＭ型ステッピングモータの一部を切り欠いて示す斜視図である。

【図１３】従来技術のハイブリッド型ステッピングモータの横断面図である。

【図１４】従来技術のハイブリッド型ステッピングモータの縦断面図である。

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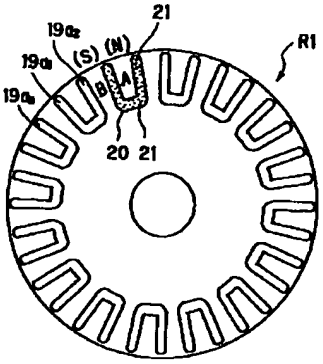
【図１５】本発明のものと従来例のものとを比較するために，ＨＢ型とＰＭ型の回転子磁極の磁束密度の分布図を示す特性図である。

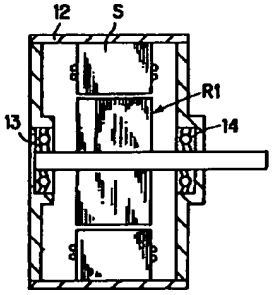
【符号の説明】

２０：Ｕ字形スリット
２１：永久磁石又はボンド磁石
Ｒ１：回転子

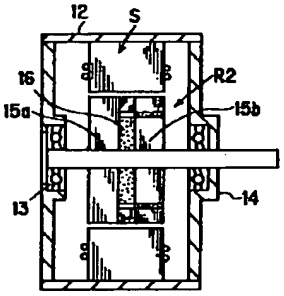
【図1】



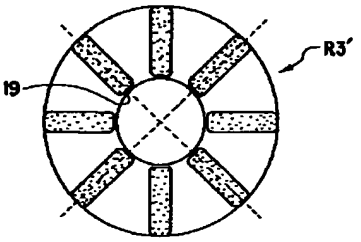
【図2】



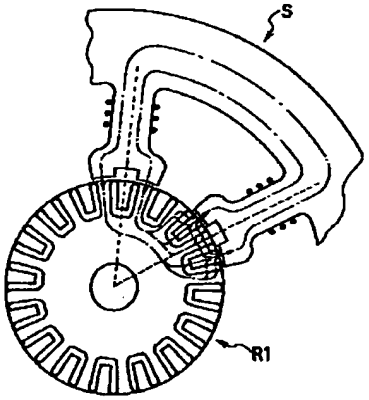
【図3】



【図5】

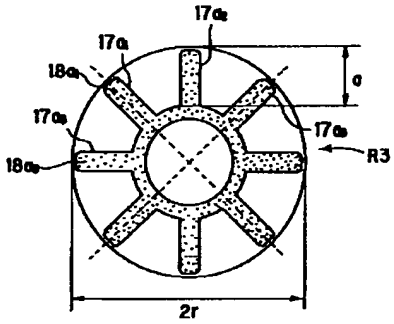


【図6】

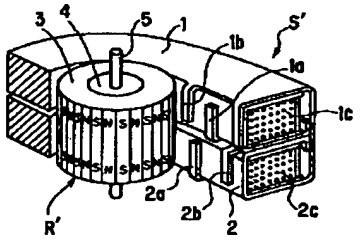


R1：回転子
20：U字状スリット
21：永久磁石又はボンド磁石

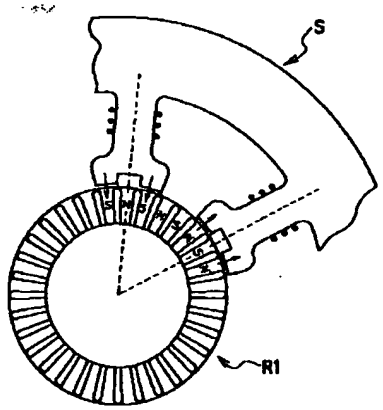
【図4】



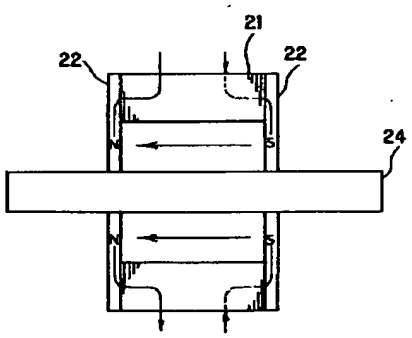
【図12】



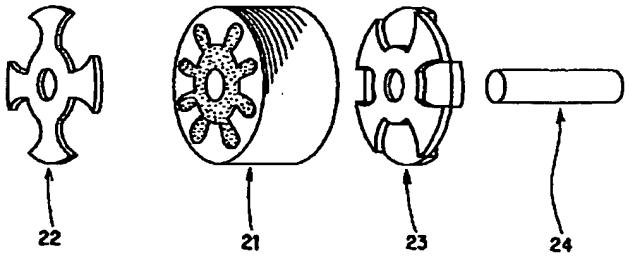
【図7】



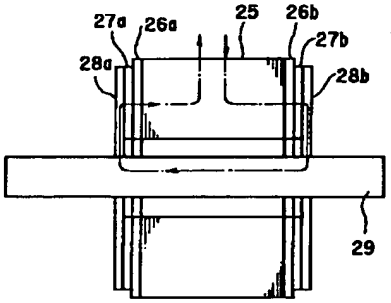
【図8】



【図9】



【図10】



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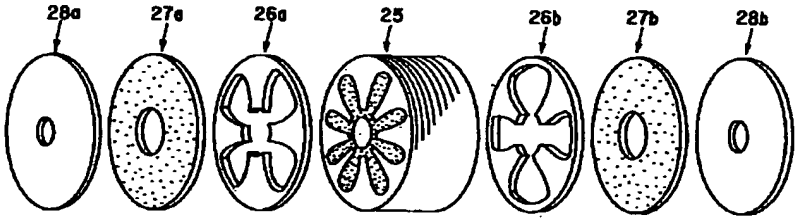

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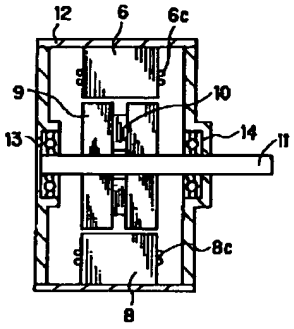

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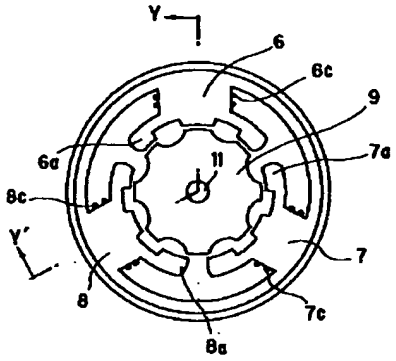

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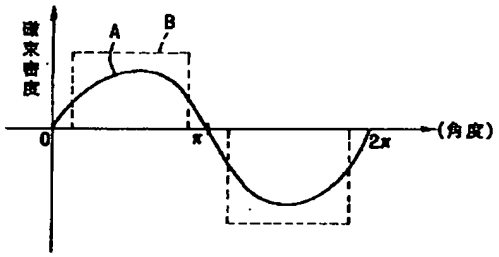

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(54) PERMANENT MAGNET ROTATING ELECTRIC MACHINE

(57)Abstract:

PURPOSE: To provide a permanent magnet rotating electric machine suitable for drum driving of LBP or the like in which magnetic flux distribution is a sinusoidal, the torque is high and cogging torque can be reduced.

CONSTITUTION: In a rotor R1 formed of a cylindrical magnetic body having a hole into which a rotating shaft is inserted in the center, a plurality of U-shaped slits 20 are provided in the periphery of this rotor at equal pitches with non-slit parts facing outward in a radial direction so that the widths (A part) of magnetic body parts between the adjacent U-shaped slits are equal to the widths (B part) of magnetic body parts which are the non-slit part in the U shape, and inside the U-shaped slits U-shaped permanent magnets or bond magnets 21 are provided, so as to magnetize the A parts and B parts of different polarity.

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CLAIMS

[Claim(s)]
[Claim 1] The periphery is approached in the rotator which changes from the magnetic substance of the shape of a cylindrical shape which has the hole which a revolving shaft penetrates to a core. Two or more non-slit sections to radial the slit of U typeface in a ** pitch outward Arrange equally and it is filled up with U typeface permanent magnet or a bond magnet in the above-mentioned U typeface slit. the width of face (A section) of the magnetic-substance section between adjoining U typeface slits, and the width of face (B section) of the magnetic-substance section which is the non-slit section in U characters -- abbreviation -- The permanent magnet type dynamo-electric machine characterized by having the rotator which magnetized the A section and the B section so that it might become heteropolarity.
[Claim 2] Z [180 degrees /] The two cylindrical shape-like magnetic substance of each other which contained the permanent magnet in two or more U typeface slits stated by claim 1 in the shifted location So that the plate-like permanent magnet magnetized two poles in the thickness direction may be pinched and the polarity of the A section by the permanent magnet of above-mentioned U typeface slit section and the B section and each magnetic polarity of the A section by the pinched above-mentioned plate-like permanent magnet and the B section may be in agreement The permanent magnet type dynamo-electric machine equipped with the rotator which comes to magnetize a slit section permanent magnet. However, Z is the number of pole gears.
[Claim 3] The permanent magnet type dynamo-electric machine considered as the configuration which does not equip U typeface slit section with a permanent magnet in the permanent magnet type dynamo-electric machine according to claim 2.
[Claim 4] It consists of the approximately cylindrical magnetic substance of outer-diameter 2r which prepared the 2Z piece slit which at least one side by the side of a periphery or inner circumference connected in the narrow width section in pitches [radial], and the slit section of a 2Z piece slit is filled up with permanent magnets, such as a bond magnet. By the 2Z piece slit The radial length of the pole section which changes with the 2Z piece magnetic substance formed It is referred to as a. n That were referred to as one or more positive integers, m= 1, 2 or 3, k= 1, or 2, are a>=pir/2Z, and filled Z=m (3n**1), Z=k (4n**1), or Z=k (5n**2), and the 2Z piece above-mentioned pole section was magnetized by heteropolarity on the periphery by turns The permanent magnet type

dynamo-electric machine which has the rotator by which it is characterized.
[Claim 5] With the permanent magnet which the direction length of a revolving shaft of abbreviation [the cylindrical shape-like magnetic substance,] was in the hole of the core by carrying out in the cylindrical shape-like magnetic substance according to claim 4, and inserted in the permanent magnet, and the 2Z piece slit section was also filled up with the permanent magnet, and was inserted in the main hole to the both ends of the cylindrical shape-like magnetic substance The pole pitch of Z pieces shifts the two magnetic substance of each other prepared in pitches [poles / Z / which were made into the shape of abbreviation isomorphism at the pole configuration each configuration of whose is 2Z piece of the cylindrical shape-like magnetic substance in a radial] 1/2 to radial [the] so that it may be made to stick. The permanent magnet type dynamo-electric machine which has the rotator characterized by having arranged, making it each of those poles of Z pieces lap with the 2Z piece pole section of the above-mentioned cylindrical shape-like magnetic substance every other piece, and magnetizing two poles in the direction of a revolving shaft.
[Claim 6] A permanent magnet is prepared in the cylindrical shape-like magnetic substance of the 2Z piece pole which the periphery connected in the narrow width section at the centrum. So that the Z poles can shift the magnetic substance of each other which had the Z poles in radial [according to claim 5] 1 / 2 pitches (180degree/Z) and the pole may lap with the 2Z piece pole of the cylindrical shape-like magnetic substance every other piece It is made to stick. The Z pole The permanent magnet type dynamo-electric machine which has the rotator characterized by having made each of the magnetic substance which it has fix an approximate circle tabular permanent magnet in the said alignment, having made each of this permanent magnet fix disc-like magnetic-substance York further, having connected these York with the revolving shaft which consists of the magnetic substance, and being magnetized in the direction of a revolving shaft at least.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to amelioration of permanent magnet type dynamo-electric machines, such as a permanent-magnet type stepping motor with little rotational vibration suitable for a laser beam printer (it omits Following LBP) etc.
[0002]
[Description of the Prior Art] Drawing 12 - drawing 15 explain the contents and the configuration of the conventional technique.
Conventional example 1: Drawing 12 is the perspective view showing the configuration of the permanent magnet type stepping motor of 2 phase type which is the conventional example 1, or a synchronous motor. In this drawing stator S' two phases It consists of the 1st stator part 1 and the 2nd stator part 2 to constitute, and the 1st stator part 1 is depended as toroidal coil 1c contained in the pole gears 1a and 1b of the shape of a ctenidium mutually combined with the inner circumference side, these pole gear 1a, and 1b. Similarly the 2nd stator part 2 Pole gear 2a, It consists of toroidal coil 2c contained in

2b, and these pole gear 2a and 2b. Here, pole gears 1a and 2a are electrical angles, for example, shift 90 degrees and are arranged. R' is a rotator, this rotator R' consists of a permanent magnet 3 magnetized so that N and the south pole might be arranged by turns at a circumferencial direction at a periphery side, a core 4, and a rotor axis 5, and bearing of the rotor axis 5 is carried out to stator S' through bearing (not shown). In this case, the magnetization pitch angle of the division angular pitch of the clo-pole of each phase of stator S' and rotator R' is constituted so that it may be mutually in agreement. Thus, since a field is given with a permanent magnet, the multipolar stepping motor and multipolar synchronous motor with which a rotator consists of a permanent magnet have good effectiveness as a revolving-field type motor, and since it is a multi-electrode, they are widely used for the direct load drive which does not use a reducer. Since an open-loop drive can be performed and the unnecessary and cheap system of a tachometer generator, an encoder, etc. becomes possible, many especially stepping motors of this structure are used. In addition, the flux density of the rotator magnetic pole of such a permanent magnet type becomes sine wave-like, as shown in A of drawing 15 . It is as follows when the distribution property of this flux density is explained further in full detail. In the thing of the structure of the permanent-magnet type (henceforth PM mold) of two phases of drawing 12 Since Rota is magnetized N and alternately with S by the periphery of a ring-like permanent magnet, Since it is distributed in the shape of a sine wave compared with an HB mold as the magnetic-flux distribution in an air gap is shown in drawing 1515 although the maximum of the flux density of an air gap is smaller than a hybrid mold (henceforth an HB mold), Seldom including harmonic content, for this reason, a flux linkage lambda serves as little rotation of vibration at running torque, seldom including an oscillating component, and when this is further analyzed from a formula, it is as follows. although the formula of torque is guided with 2 phase machine for simplification of count -- the following (1) - (4) type -- (5) types -- moreover, (6) types are called for as theta=omegat by (5) formulas. In addition, for lambdaa, the maximum of a flux linkage, and k1 and k2 are [a phase flux linkage and lambdab of b phase flux linkage and phim] constants here, respectively. Moreover, ia is [b phase current and im of a phase current and ib] the maximums of a current. lambdaa=phim [k1costheta+k3cos3theta] ..... (1)
lambdab=phim [k1costheta+k3cos3theta] ..... (2)
ia=Imcos (omega t+alpha) ..... (3)
ib=Imsin (omega t+alpha) ..... (4)
T=(dlambda/dtheta) i =phimIm [k1sin(omega t+alpha-theta)-3k3sin (omega t+alpha+3theta)]
..... (5)
As theta=omegat T=phi mIm [k1sinalpha-3k3sin (4 theta+alpha)] ..... (6)
(6) The 2nd term of a formula expresses vibratory torque. In the thing of a permanent-magnet type, considering being set to k3=0, an oscillating component disappears and (6) types serve as a low oscillating rotary motor.
[0003] Conventional example 2: Drawing 13 and drawing 14 show the stepping motor of the HB mold of three-phase-circuit 3 pole which hits the conventional example 2, respectively, and drawing 13 is a crossing side elevation and a sectional view [in / in drawing 14 / the Y-Y' line of drawing 13], and they show the example of a variety mold. In each drawing, the pole gear by which 6-8 were prepared in the stator magnetic pole, and 6a-8a were prepared in the inside side, respectively, and 6c-8c are exiting coils,

respectively. As for a rotor axis and 12, casing, and 13 and 14 are [the rotator which 9 fastens a permanent magnet 10 and changes, and 11] bearing. In addition, the flux density of the rotator magnetic pole of such an HB mold becomes abbreviation square wave-like, as shown in B of drawing 15 . Moreover, in the rotator of the HB mold of this configuration, since N pole and the south pole separate into shaft orientations and serve as a magnetic tooth of a convex pole, the part of a convex pole magnetic tooth has [magnetic-flux distribution of an air gap with a stator] equally strong flux density, and a crevice serves as distribution near zero. For this reason, many space higher harmonics will be contained in the flux linkage lambda with the stator coil of the Rota magnetic flux, and an oscillating component is contained in running torque.

[0004]

[Problem(s) to be Solved by the Invention] by the way, there were the following troubles in the thing of the example of since [above-mentioned / each] **. In the case of the conventional example 1: Since ** rotator is magnetized N and alternately with S by the periphery of a ring-like permanent magnet, the maximum of the flux density of an air gap is smaller than the HB mold of the conventional example 2, but since the magnetic-flux distribution in an air gap is distributed in the shape of a sine wave compared with an HB mold like drawing 15 , a flux linkage lambda serves as little rotation of vibration comparatively, including respectively harmonic content and the oscillating component of running torque only in a few. However, this invention cannot say that the field of an oscillation characteristic is still enough as an object for LBP made into the application application.

** Compared with the thing of an HB mold, torque serves as smallness.

** A step angle (resolution) is not small made for 2 phase type. In the case of the conventional example 2: Compared with the thing of the permanent magnet type of the ** conventional example 1, as shown in drawing 15 , flux density serves as a large next door, and torque serves as size.

** However, since N pole and the south pole divide the rotator of an HB mold into shaft orientations and it has become the magnetic tooth of a convex pole, the part of a convex pole magnetic tooth has [magnetic-flux distribution of an air gap with a stator] equally strong flux density, and a crevice serves as distribution near zero. For this reason, many space higher harmonics will be contained in the flux linkage lambda with the stator coil of rotator magnetic flux. Therefore, an oscillating component is contained in running torque. This invention aims at offering the permanent magnet type dynamo-electric machine which solved the above-mentioned technical problem (trouble) of the conventional thing.

[0005]

[Means for Solving the Problem] In the rotator which changes from the magnetic substance of the shape of a cylindrical shape which has the hole which a revolving shaft penetrates to a core in order that the permanent magnet type dynamo-electric machine of this invention may solve the above-mentioned technical problem The periphery is approached. Two or more non-slit sections to radial the slit of U typeface in a ** pitch outward Arrange equally and it is filled up with U typeface permanent magnet or a bond magnet in the above-mentioned U typeface slit. the width of face (A section) of the magnetic-substance section between adjoining U typeface slits, and the width of face (B section) of the magnetic-substance section which is the non-slit section in U characters --

abbreviation -- It considered as the configuration equipped with the rotator which magnetized the A section and the B section so that it might become heteropolarity. Z [180 degrees /] The two cylindrical shape-like magnetic substance of each other which contained the permanent magnet in two or more U typeface slits in this case, in the shifted location So that the plate-like permanent magnet magnetized two poles in the thickness direction may be pinched and the polarity of the A section by the permanent magnet of above-mentioned U typeface slit section and the B section and each magnetic polarity of the A section by the pinched above-mentioned plate-like permanent magnet and the B section may be in agreement It is desirable to consider as the configuration equipped with the rotator which comes to magnetize a slit section permanent magnet. However, Z is the number of pole gears. Moreover, it is good also as a configuration which does not equip U typeface slit section with a permanent magnet. It consists of the approximately cylindrical magnetic substance of outer-diameter 2r which prepared the 2Z piece slit which at least one side by the side of a periphery or inner circumference connected in the narrow width section in pitches [radial], and the slit section of a 2Z piece slit is filled up with a bond magnet or a permanent magnet. Moreover, by the 2Z piece slit The radial length of the pole section which changes with the 2Z piece magnetic substance formed It is referred to as a. n It can also constitute so that it is referred to as one or more positive integers, m= 1, 2 or 3, k= 1, or 2, and it may be a>=pir/2Z, and Z=m (3n**1), Z=k (4n**1), or Z=k (5n**2) may be filled and the 2Z piece above-mentioned pole section may be magnetized by heteropolarity on the periphery by turns. With in this case, the permanent magnet which that direction length of a revolving shaft of abbreviation [the cylindrical shape-like magnetic substance,] was in the hole of that core by carrying out in the above-mentioned cylindrical magnetic substance, and inserted in the permanent magnet, and the 2Z piece slit section was also filled up with the permanent magnet, and was inserted in the main hole to the both ends of the cylindrical shape-like magnetic substance The pole pitch of Z pieces shifts the two magnetic substance of each other prepared in pitches [poles / Z / which were made into the shape of abbreviation isomorphism at the pole configuration each configuration of whose is 2Z piece of the cylindrical shape-like magnetic substance in a radial] 1/2 to radial [the] so that it may be made to stick. It is desirable to consider as the configuration which have arranged, and it is made for each of those poles of Z pieces to lap with the 2Z piece pole section of the above-mentioned cylindrical shape-like magnetic substance every other piece, and was magnetized two poles in the direction of a revolving shaft. Moreover, as shown in drawing 4 , prepare a permanent magnet in the centrum at the cylindrical magnetic substance of the 2Z piece pole which the periphery connected by details, and the Z poles shift the magnetic substance of each other which had the Z poles in radial [which was stated for the preceding clause] 1 / 2 pitches (180degree/Z). So that the pole may lap with the 2Z piece pole of the cylindrical magnetic substance every other piece It is desirable to make it stick, to make each of the magnetic substance with the Z pole fix an approximate circle tabular permanent magnet in the said alignment, to make each of this permanent magnet fix disc-like magnetic-substance York further, to connect these York with the revolving shaft which consists of the magnetic substance, and to be magnetized in the direction of a revolving shaft at least.

[0006]

[Function] In the above configurations, if the sufficiently large sum of the radius lay

length of the slit is taken in order that the magnetic flux generated from the permanent magnet (bond magnet) with which the slit section radial [the] was filled up may gather for the magnetic pole on a periphery, if the large sum of the die length of the two radial slit sections of a U character-like slit is taken rather than the magnetic pole width of face on a periphery, flux density of a magnetic pole can be enlarged like the conventional HB mold. And in order for flux density to serve as zero in the contiguity section of N pole and the south pole since N pole and the south pole are arranged by turns, and to be reversed, compared with an HB mold, it becomes distribution of the form near a sine wave, and becomes advantageous to the reduction in vibration at the time of motor rotation. Moreover, since the thing of an HB mold serves as the so-called three-dimension magnetic path to which magnetic flux passes through the inside of a stator core to rotator shaft orientations, after interlinking with a stator coil the magnetic flux in which the permanent magnet type dynamo-electric machine by this invention appeared from N pole of a rotator to magnetic reluctance becoming large in a flat surface perpendicular to a rotor axis, it can return to the south pole of a rotator. Therefore, since magnetic-path length does not need to become short, either and magnetic flux does not need to pass it along a laminating griddle in the direction of a revolving shaft compared with the thing of an HB mold, magnetic reluctance also becomes small. Moreover, since N pole and the south pole cover the overall length of a stator and an opposed face product with the stator magnetic tooth seen from the rotator can also counter, torque also increases. In addition, in the thing of an HB mold, it is half-pitch gap ****** of a rotator magnetic tooth at the die length of 2 about 1/.

[0007]

[Example] Each example shown in drawing 1 - drawing 11 below explains this invention concretely.

Example 1: Drawing 1 thru/or drawing 2 explain the configuration of the example 1 of this invention. the thin electromagnetism to which a rotator R1 changes from the magnetic substance as drawing 1 is the cross-sectional view having taken out and shown the rotator of an example 1 and it is shown in this drawing, although a griddle is pierced with a press, and it considers as a rotator or iron powder can really be made from sintering etc. with shaping Are the rotator which changes from the magnetic substance of the shape of a cylindrical shape with the hole which can penetrate a revolving shaft to a core, and the periphery is approached. Prepare slit 19a1-19an in a radial in pitches, such as 2Z piece, and these slits are connected by suitable die length (depth) every other piece. Form the slit 20 of the shape of Z character [U], and these Z U character-like slits 20 are filled up with the bond magnet 21. By magnetizing the magnetic substance B of the width-of-face section of U character spacing in case the U character slit 20 adjoins the magnetic-substance section A surrounded on U character-like the inside and a periphery so that it may become heteropolarity in the periphery section respectively, N pole and the south pole consider as the permanent magnet type dynamo-electric machine which has Z logarithms by turns on the periphery. According to the structure of this invention, flux density of a magnetic pole can be carried out more than the flux density of the permanent magnet itself by taking the large sum of radial slit section die length of two pieces of a U character slit from the die length which broke the periphery length by 2Z, i.e., magnetic pole width of face. In addition, it replaces with a U character-like bond magnet, and you may make it equip the U character-like slit 20 with a permanent magnet. Drawing 2

separates an air gap to Stator S, the permanent-magnet type dynamo-electric machine of the example 1 which incorporated and constituted the rotator R1 shown in drawing 1 is shown, and Stator S can use the same thing, if the number of teeth of a rotator is combined with Z pieces with the conventional HB mold stepping motor. Therefore, casing 12 and bearing 13 and 14 attached and showed the same sign as the thing of drawing 14 .

[0008] Example 2: The thing of this example is constituted as shown in drawing 3 . That is, two rotator components 15a and 15b of the same structure as the rotator R1 shown in drawing 1 are pinched for 180 degrees / disc-like permanent magnet 16 which shifted Z times, has arranged and was magnetized two poles in the middle of each other in the shape of sandwiches, and the rotator R2 connected with the revolving shaft is constituted combining the same stator S as drawing 2 . The thing of this example can expect the effectiveness by the configuration of an example 1, and reinforcement of the further magnetism by the thing of the conventional HB mold. Namely, the contents fit into the periphery of the disc-like permanent magnet 16 which carried out 2 pole magnetization in the thing of this example, and the outer diameter is below a rotator outer diameter. Two rotator components 15a and 15b which the thickness is the same magnetic substance as the thickness of above-mentioned 2 pole magnet, has the 2Z piece slit of pitches [radial direction], double a slit location with the magnetic substance connected by details with the outer diameter or bore, and are shown in drawing 3 If it connects magnetically, since the magnetic flux of the permanent magnet 16 of 2 pole magnetization of the thing of an HB mold will reach the whole rotator R2 and the permanent magnet is moreover contained in the U character mold, the magnetic leakage flux between N pole and the south pole also serves as little powerful N and S mutual magnetization rotator.

[0009] Example 3: It is that with which the rotator was prepared in the 2Z piece (Z= 4 [in this case]) slit 17a1 to 17a8 by the magnetic griddle in the shape of a chrysanthemum, and that periphery connected the thing of this example by details as shown in drawing 4 , and a slit is filled up with the permanent magnets 18a1 to 18a8, such as a plastics magnet, and a rotator R3 is constituted. If 2Z piece (they are eight pieces at n= 4 in this case) radius lay length which sets the die length of 2r and rotator shaft orientations to L, and can do an outer diameter to a 2Z piece slit at this time is set to a, the relation between a>=pi r / 2Z will be filled, and the periphery section of the 2Z piece above-mentioned pole will be magnetized alternately with N pole and the south pole. The magnetic pole width of face which is the pole of a rotator periphery is 2pirL/2Z, and the normal of a slit section magnet and the area of the direction of a right angle are aL(s), and in order for magnetic flux to occur from the magnet of both sides and to centralize magnetic flux on 2pirL/2Z enough, they are set to a>=pi r / 2Z that what is necessary is just 2aL(s)>=2pirL/2Z. Although the pole is abbreviation isomorphism-like in the rotator R3 which shows rotator R3' shown in drawing 5 to drawing 4 , it is what deformed so that the inner circumference might connect in the narrow width section 19, and even if constituted in this way, it can become N and S mutual magnet. Although the rotator of an example is a rotator effective in the so-called permanent-magnet type stepping motor (drawing 8) of a clo-pole mold stator, it can also be used combining the stator of the conventional HB mold stepping motor. In this case, in the case of 2 phase stepping motor, the relation of (7) types shown by the following (several 1) is materialized.

[Equation 1]

$$\frac{90°}{Z} = \pm \left\{ \frac{360°}{4m} - \frac{360°}{Z} n \right\} \qquad \cdots\cdots(7)$$

Moreover, in the case of a three-phase-circuit stepping motor, the relation of (8) types shown by the following (several 2) is materialized.
[Equation 2]

Furthermore, in the case of 5 phase stepping motor, the relation of (9) types shown by the following (several 3) is materialized.
[Equation 3]

Although relational expression with the 2Z was shown in the above-mentioned (7) - (9) type, the angle and the 2nd term in which, as for the 1st term of the right-hand side, the main lobe of a stator constitutes a step angle are the location of a rotator magnetic tooth with the left part nearest to [all] the main lobe, and the right-hand side also expresses a step angle. When this (7) - (9) type is arranged, it is Z=m (3n**1).
Or it becomes Z=k (4n**1) or Z=k (5n**2), and it is necessary to fill the relational expression of this Z. 4 phase stepping motor is contained in the formula of Z in 2 phase machine in part. Here, n sets 1, 2 or 3, and k as one or more positive integers, and m sets them to 1 or 2.
[0010] next, drawing 1 -- or -- drawing 4 -- the magnetic path when combining a rotator with a stator is explained. The rotator shown in drawing 1 or drawing 4 by this invention is considered as the configuration which can expect bigger torque than the PM mold stepping motor conventional by combining with the stator of PM mold instead of the rotator of PM mold stepping motor which is the conventional technique shown in drawing 12 . As it was mentioned above, it is because flux density can be made higher than the flux density of the permanent magnet itself by centralizing the magnetic flux of a permanent magnet on a magnetic pole. Since the stator of PM mold is a clo-pole mold, even if it combines with the rotator shown in drawing 4 , since the magnetic flux which came out from the N pole can return to the adjoining south pole immediately through the stator magnetic path of the clo-pole, it is very effective. However, since the magnetic flux which came out from N pole cannot necessarily return to the adjoining south pole after passing along a stator magnetic path, as shown in drawing 7 when combining with the stator of the conventional HB mold stepping motor, in the case of the structure of drawing 4 , a magnetic path may open, and effectiveness falls in that case. Although PM mold is naturally effective in the thing of the structure of drawing 1 , since a magnetic path turns into a closed magnetic circuit as the alternate long and short dash line surely showed as an HB mold stator also shows to drawing 6 , it can be extremely called large invention of the use range. In addition, each rotator shown in drawing 1 , drawing 6 , and drawing 7 is an example at the time of being referred to as Z= 16.
[0011] Example 4: The vertical section front view in which drawing 8 shows the configuration of the example 4 of this invention, and drawing 9 are the decomposition

perspective views of each component of drawing 8 . As the thing of this example prepares what made this ** mostly the magnetic-flux distributor 22 which had the Z poles in the direction of a periphery, or 23 at the pole configuration the pole configuration of whose is 2Z piece of drawing 4 in both the sides in Rota 21 of the example 1 shown in drawing 1 and it is shown in drawing 9 The pole pitch of Z pieces shifts two magnetic-flux distributors 22 or 23 1/2, and it is made to stick to the 2Z piece pole of Rota of drawing 1 , and fixes in the rotor-shaft 24 grade which consists of non-magnetic material, and two poles are magnetized to shaft orientations and it considers as Rota. In addition, the magnetic-flux distributor 23 ** one griddle half-partially, and forms it. Although the case where it constituted from drawing 9 so that it may face across Rota 21 by the magnetic-flux distributor 22 and the magnetic-flux distributor 23 from which structure is different was illustrated, you may constitute so that it may face across Rota 21 by the two same magnetic-flux distributors 22 or the magnetic-flux distributor 23. Two poles of permanent magnets are magnetized in the direction of a revolving shaft, and the work carries out distribution supply of the magnetic flux so that it may become N pole and the south pole from the both sides of 2Z piece magnetic-substance Rota York every other [of the 2Z piece pole] piece with the Z poles about what received the magnetic flux of a permanent magnet by the above-mentioned magnetic-flux distributor 22 or 23. Since the permanent magnet between 2Z piece slots is magnetized in the direction of a revolving shaft at this time, the leakage between the 2Z piece poles can be prevented to some extent. if radial magnetization is added with the magnetization current of extent by which the radial magnetization only of the permanent magnet (magnet) of the slot section for 2 Z pieces is carried out after magnetizing this invention article Rota of drawing 8 to shaft orientations -- the 2Z piece magnet between slots -- a radial direction -- moreover, since the magnet of the Rota core is magnetized in the axial direction, leakage of the 2Z piece magnetic substance can also be prevented, and the magnetic pole of powerful Rota is formed. In addition, although the proposal which combines ctenidium Rota York of two sheets and fills up a plastics magnet with the advanced technology shown in JP,3-124772,U is shown, the thickness of the part which ctenidium York is bent by the shaft orientations from the structure, and serves as a magnetic tooth on the Rota periphery is decided by board thickness, the ctenidium width of face becomes thin when a pole increases, the pole becomes wire-like at the whole, for sending the magnetic flux of a permanent magnet to a tip, magnetic reluctance becomes high, and high torque cannot be expected. In the thing of this invention, if a shown by drawing 4 is chosen appropriately, this problem is solvable. Moreover, in a ctenidium, when it becomes a multi-electrode, since the pole is a wire-like and the location precision is deflection, there is also a problem that it does not come out well. Since this invention extracts a griddle with a press, it is accurate.

[0012] Example 5: Drawing 10 and drawing 11 are the vertical section front views and decomposition perspective views showing the configuration of the example 5 of this invention, respectively. The slot section pinched with the 2Z piece magnetic substance of drawing 1 As shown in both the sides of the body of revolution 25 which comes to fill up permanent magnets, such as a plastics magnet, at drawing 10 and drawing 11 The magnetic-flux distributors 26a and 26b are 2 pitch ** carried out [1 /] by the same physical relationship as drawing 9 . After making it stick, arranging the permanent magnets 27a and 27b, such as thin neodium, on outside both that side, sticking the

magnetic substance 28a and 28b on outside both that side further and connecting this magnetic substance in the bore cavernous section of the 2Z piece above-mentioned pole with the magnetic-substance revolving shaft 29, by being magnetized to the two poles 2n pole is magnetized every other piece so that the magnetic flux of the permanent magnet of two sheets may serve as N pole and the south pole respectively, and the same effectiveness as drawing 8 is acquired. With the magnetic-substance revolving shaft 29, two permanent magnets 27a and 27b form the magnetic path containing a stator, and can make a powerful field. In the configuration of drawing 10 and drawing 11 , if a magnetic plate like magnetic-substance 28a (28b) is put in between magnetic-flux distributor 26a (26b) and permanent magnet 27a (27b), a still more powerful field can be made.

[0013] Rota of drawing 1 which showed each example which this invention mentioned above - drawing 11 Although it can become high torque from the conventional PM mold motor if it is used as a substitute of Rota which carried out the bobbin volume of the clo-pole stator which is the conventional PM mold 2 phase machine, and magnetized the periphery of cylinder ring coils, such as a ferrite, to Z logarithms alternately with N and the south pole In order that the clo-pole of this PM mold 2 phase machine mentioned above may bend the ctenidium-like pole and may make it a stator bore, the homogeneity of an air gap is not good under the effect of the springback of the bent pole, therefore it is disadvantageous at vibration etc. On the other hand, if a stator is used as the conventional HB mold stator as shown in drawing 6 , and it combines with this invention Rota, an air gap will also become homogeneity and the real value of this invention will be demonstrated further.

[0014] Drawing 15 is the schematic diagram which measured the flux density from the conventional HB mold and the permanent magnet of one magnetic pole of this invention R> 1, for example, drawing 1 , and becoming sine wave-like, as shown in this drawing A is shown by N pole of this invention, and the thing of a south pole mutual mold to becoming a square wave as flux density shows the thing of an HB mold to B of drawing 15 .

[0015]

[Effect of the Invention] Since the permanent magnet type dynamo-electric machine of this invention is constituted as mentioned above, it has the following outstanding effectiveness.

** It can realize by high torque equivalent to an HB mold stepping motor, and the approach with cheap low vibration more than the conventional PM mold and low noise property, and multipolarization is also possible.

** Since the opposed face product of a stator and a rotator becomes twice the conventional HB mold, the part and a flux linkage can be increased.

** Since not the magnetic tooth of a convex pole but N pole and the south pole adjoin like an HB mold rotator, flux density is distributed in the shape of a sine wave, the cogging torque of stator deenergisation can be decreased, and the step angle precision at the time of a micro step drive also improves.